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ELECTRICAL TRANSMISSION SYSTEM

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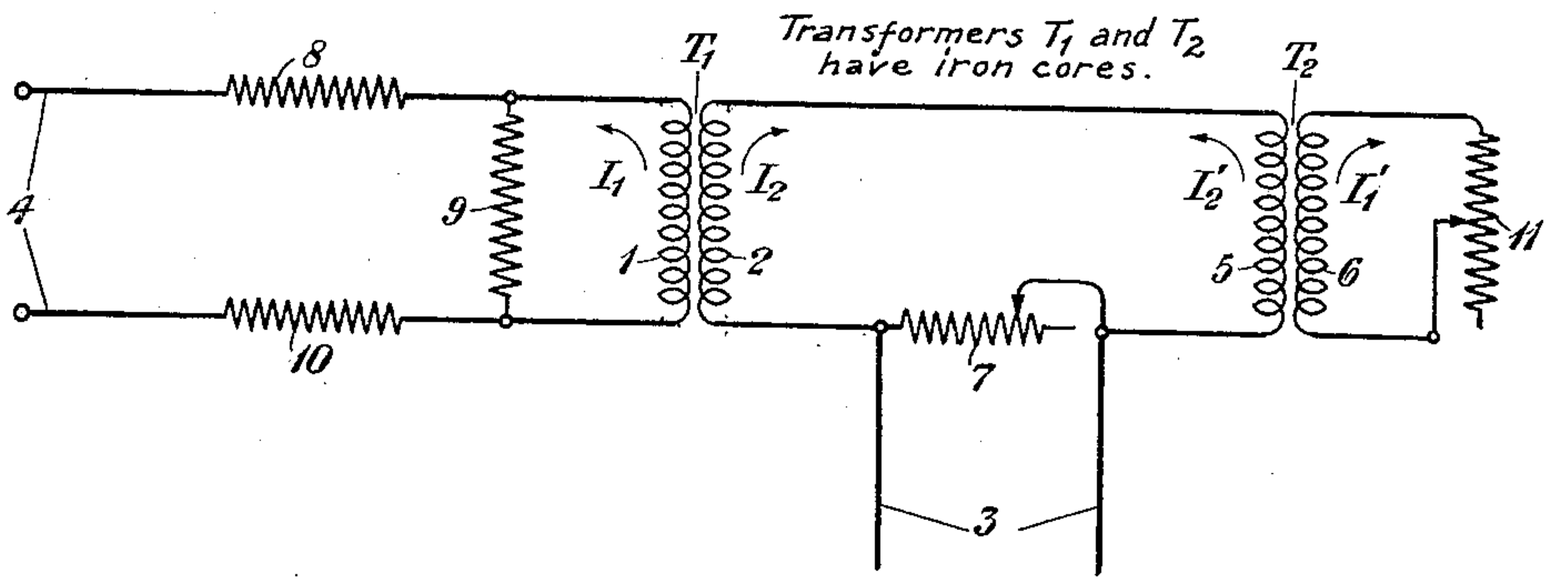

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ELECTRICAL TRANSMISSION SYSTEM

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This invention relates to electrical transmission systems, and particularly to arrangements in such systems for transmitting the fundamental frequency of a source to a receiving circuit through a transformer without the introduction of harmonics of the fundamental frequency by the transformer.

In systems for the transmission of a fundamental frequency of a source to an output or receiving circuit, it is often necessary to isolate the output or receiving circuit from the source of fundamental frequency by means of a transformer interconnecting the source of current and the output or receiving circuit. The transformer will of itself generate harmonics which will also be transmitted to the output or receiving circuit along with the fundamental frequency. In systems in which the wave shape of the current in a source is to be faithfully reproduced in an output or receiving circuit, it is very often necessary to provide arrangements for eliminating or minimizing the effect of these harmonics on the wave shape of the current of the source.

Accordingly, it is an object of this invention to provide arrangements in a system in which a transformer interconnects a source of fundamental frequency and an output circuit for eliminating the harmonics of the fundamental frequency generated in the transformer.

It is another object of this invention to isolate a source of current from an output or receiving circuit by means of transformers in such a manner as to eliminate the harmonics or other currents which might be introduced by the transformers.

It is another object of this invention to provide arrangements for balancing the harmonics of a fundamental frequency introduced by a transformer by harmonics of equal magnitude and of opposite phase.

While the invention will be defined in the appended claims, the further objects and features of the invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing showing one embodiment of the invention.

Referring to the drawing, a transformer T_1 is shown having a primary winding 1 and a secondary winding 2. The transformer T_1 isolates an output or receiving circuit connected to the leads 3 from a source of current of fundamental frequency connected to the leads 4. A second transformer T_2 having a secondary winding 5 and a primary winding 6 is so related to the transformer T_1 as to balance out harmonics generated in the first transformer, as will be better understood from the description hereinafter following. The secondary windings of the transformer T_1 and T_2, which may preferably have the same constants, are interconnected through a variable resistance 7 in the circuit including the secondary winding 2 of the transformer T_1, the secondary winding 5 of the transformer T_2 and the variable resistance 7. Three resistances 8, 9 and 10 are in series with the source of current connected to the leads 4, the resistance 9 being bridged across a primary winding 1 of the transformer T_1. These resistances 8, 9 and 10 are used to eliminate the effect of the impedance of the source of current connected to the leads 4 on the output or receiving circuit connected to the leads 3. An adjustable impedance 11 is bridged across the primary winding 6 of the transformer T_2.

Current from the source connected to the leads 4 passes through the resistances 8, 9 and 10, effecting a drop in potential across the resistance 9. Due to the relationship existing between the primary winding 1 of the transformer T_1 and the resistance 9, the current from the source will also be impressed upon the primary winding 1 of the transformer T_1. As is well known in the art, harmonics of a fundamental frequency of the source will be introduced by the transformer T_1, these harmonics having the values of I_1 amperes and I_2 amperes in the primary and secondary circuits, respectively. Similarly, the application of the fundamental frequency to the transformer T_1 results in the circulation of harmonics of the fundamental frequency in the primary and secondary circuits of the transformer T_2, these harmonics being generated in the transformer T_2 and

having the values of I_1' amperes and I_2' amperes in the primary and secondary circuits of the transformer T_2, respectively.

The voltage of the fundamental frequency induced in winding 2 of transformer T_1 is substantially in phase opposition to the voltage of that frequency impressed upon winding 1. Due to the non-linear hysteresis characteristics of the iron core of transformer T_1, harmonic voltages are generated in windings 1 and 2, the voltages in winding 2 bearing a definite phase relation to the voltage of the fundamental frequency in winding 2. The voltage of the fundamental frequency in winding 2 also becomes impressed upon winding 5 of transformer T_2. As in the case of transformer T_1, harmonic voltages are similarly generated in both windings 5 and 6 of transformer T_2. The harmonic voltages induced in winding 5 will have the same phase relation to the current of the fundamental frequency as the harmonic voltages in winding 2 had to the current of the fundamental frequency in the latter winding. The harmonic voltages generated in transformers T_1 and T_2 will cause harmonic currents to circulate in the attached circuits, as indicated by the arrows adjacent to the reference characters I_1, I_2, I_1', and I_2'. Since the harmonic voltages induced in winding 2 bears the same phase relation to the fundamental voltage in winding 2 as the harmonic voltages generated in winding 5 bear to the fundamental voltage applied to winding 5, then in the local circuit, including windings 2 and 5 and resistance 7, the two sets of harmonic voltages will result in currents I_2 and I_2', which are substantially in phase opposition.

The variable resistance 7 is included in a series circuit with the secondary winding 2 of the transformer T_1 and the secondary winding 5 of the transformer T_2. For a given value of resistance 7, by adjusting the impedance 11, the harmonics of the fundamental frequency I_2 amperes and I_2' amperes, in the secondary winding 2 of the transformer T_1 and in the secondary winding 5 of the transformer T_2, respectively, may be made equal in magnitude and opposite in phase. Consequently, when this adjustment is made, the harmonics of the fundamental frequency generated in the secondary winding 2 of transformer T_1 will be neutralized by the harmonics generated in the secondary winding 5 of the transformer T_2, and therefore there will be no current flowing through the resistance 7 due to the harmonics. The voltage drop across the resistance 7, being applied to the output or receiving circuit 3, will then effect a faithful reproduction of the wave shape of the current of the source connected to the leads 4 in the output or receiving circuit connected to the leads 3, which is substantially free from harmonics generated in either transformer.

It will be understood, however, that the harmonics generated in the transformer T_1 may be balanced or neutralized by equal harmonics generated by an iron core inductance coil of the proper size if placed in the circuit in the position of the transformer T_2 in parallel relationship with impedance 11.

While the invention has been disclosed in one particular embodiment, which is deemed desirable, it is to be understood that it is capable of embodiment in other and widely varied organizations without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. The method of eliminating the harmonics of a fundamental frequency generated in a transformer connected to a source of fundamental frequency with apparatus including a second transformer, which consists in generating the same harmonics in the second transformer, and balancing out these harmonics without affecting the fundamental frequency.

2. A system for eliminating the harmonics of a fundamental frequency generated by a two-winding transformer connected to a source of the fundamental frequency, comprising a second two-winding transformer, means for generating the same harmonics in the second transformer, and means for balancing out these harmonics without affecting the fundamental frequency.

3. A system for eliminating the harmonics generated in a transformer connected to a source of fundamental frequency comprising a second transformer, each of said transformers having first and second windings, a resistance, and means for generating in the second transformer harmonics of the fundamental frequency which are equal in magnitude and opposite in phase to those harmonics generated in the transformer connected to the source of fundamental frequency, the second windings of the transformers being arranged in a series circuit with the resistance.

4. In combination, a source of fundamental frequency, two transformers each having first and second windings, the first winding of one of said transformers being connected to the source of fundamental frequency, and an adjustable resistance, the second windings of said transformers being connected to the resistance in a local circuit, the resistance being adjusted so that the currents of the harmonics of the fundamental frequency generated therein are equal in magnitude and opposite in phase.

5. A system for faithfully reproducing in an output circuit the current of a fundamental frequency of a source comprising two transformers each having first and second windings, a variable resistance, the first wind-

ing of one transformer being connected to the source, the second windings of said transformers being arranged in a local circuit with the variable resistance, and an adjustable impedance connected to the first winding of the other transformer, currents being produced in the latter transformer equal in magnitude and opposite in phase to those produced in the transformer connected to the source.

6. In combination, a source of fundamental frequency, two transformers each having only first and second windings, an impedance which may be fixed at a definite value, and a variable impedance, the first winding of one of the transformers being connected to the source of fundamental frequency, the first winding of the other of the transformers being connected to the first mentioned impedance, the second windings of said transformers being arranged in a series circuit with the second mentioned impedance.

7. In combination, a source of fundamental frequency, an output circuit, a transformer having first and second windings, the first winding of said transformer being connected to the source of fundamental frequency, and means for reproducing the fundamental frequency in the output circuit through the transformer without introducing harmonics of the fundamental frequency generated by the transformer, said means comprising another transformer, a resistance connected to said output circuit, and an impedance connected to the first winding of the latter transformer, the second windings of said transformers being arranged in a series circuit with the resistance.

8. In combination, a source of fundamental frequency, an output circuit for receiving the fundamental frequency, and means for isolating the output circuit from the source of fundamental frequency without introducing the harmonics of the fundamental frequency, said means comprising two transformers, each having first and second windings, a rheostat connected to the output circuit, and a variable impedance, the second windings of the transformers being arranged in a series circuit with the rheostat, the first winding of one of the transformers being connected to the source of fundamental frequency, the first winding of the other of the transformers being connected to the variable impedance.

9. In combination, a source of fundamental frequency, an output circuit, and means for faithfully reproducing the fundamental frequency in the output circuit without the introduction of the harmonics of the fundamental frequency, said means comprising two transformers each having first and second windings, the first winding of one of the transformers being connected to the source of fundamental frequency, and an impedance connected to the first winding of the other of said transformers, the second windings of said transformers being connected in series with the output circuit, one transformer setting up harmonics of the fundamental frequency due to the impedance associated therewith, which are equal in magnitude and opposite in phase to those set up by the other transformers due to its connection with the source of fundamental frequency.

10. The method of eliminating the harmonics of a fundamental frequency generated in a transformer connected to a source of fundamental frequency with a second transformer, each of said transformers having first and second windings, the second windings of said transformers being connected in a series circuit with a resistance, which consists in generating in the second transformer the same harmonics and adjusting the harmonics generated in the second transformer so as to be opposite in phase to those generated in the first transformer.

In testimony whereof, I have signed my name to this specification this 26th day of February, 1926.

PAUL W. BLYE.